

# ACS TQIP BEST PRACTICES IN THE MANAGEMENT OF ORTHOPAEDIC TRAUMA



COMMITTEE  
ON TRAUMA



AMERICAN COLLEGE OF SURGEONS  
*Inspiring Quality:  
Highest Standards, Better Outcomes*



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## INTRODUCTION

More than 60 percent of injuries involve the musculoskeletal system, and more than half of hospitalized trauma patients have at least one musculoskeletal injury that could be life threatening, limb threatening, or result in significant functional impairment. These orthopaedic injuries are often associated with significant health care costs, decreased productivity in the workplace, and, in some cases, long-term disability. The optimal management of trauma patients with orthopaedic injuries requires significant physician and institutional commitment. The American College of Surgeons (ACS) Resources for the Optimal Care of the Injured Patient, 2014 includes several key hospital and provider-level orthopaedic trauma criteria that must be met in order to attain American College of Surgeons trauma center verification. Although these criteria are important, they do not cover the entire breadth of orthopaedic trauma care. Furthermore, trauma centers may identify areas in need of improvement that are unique to their hospital. These best practice guidelines represent a compilation of the best evidence available for each respective topic. In areas where the literature is inconclusive, incomplete, or controversial, expert opinion is provided. As such, there are several points worth mentioning:

- All facilities should have in place appropriate pain management guidelines for those suffering from traumatic orthopaedic injury.
- All patients with orthopaedic injuries should be preferentially placed in hospital units staffed by nurses who receive ongoing orthopaedic-specific in-service training.
- For high-risk injuries, facilities should have guidelines ensuring ongoing neurovascular assessments prior to fixation.
- When appropriate, prosthetics counseling, evaluation, and implementation should be made available in a timely manner.

In addition to an outline of best practices, we have also included appropriate performance improvement (PI) indicators (Appendix A) that you might use as a guide to continually evaluate the delivery of orthopaedic trauma care in your center.



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# TRIAGE AND TRANSFER OF ORTHOPAEDIC INJURIES

## Key Messages

- Optimal care of orthopaedic injuries occurs when both the health care providers and hospitals are capable of providing high-quality care. Patients with a combination of TBI (GCS score  $\leq 15$ ) and moderate to severe extra-cranial anatomic injuries and Abbreviated Injury Score (AIS)  $\geq 3$  should be rapidly transferred to the highest level of care within a defined trauma system to allow for expedient neurosurgical and multidisciplinary assessment and intervention
- Hospitals should develop protocols and procedures for identifying patients with orthopaedic injuries who are likely to benefit from transfer to a designated trauma center.
- Certain orthopaedic injuries always warrant strong consideration for transfer to a designated trauma center.
- In the setting of concurrent injuries, co-morbidities, or extremes of age, strong consideration should be given to transferring patients with minor orthopaedic injuries.
- Transfer agreements between hospitals can facilitate the timely transfer of injured patients.

- Direct communication between transferring and receiving institutions is important prior to patient transfer and when breakdowns in the transfer process occur.

The optimal care of patients with musculoskeletal injuries relies upon the orthopaedic provider and the institution at which he or she practices. Although an individual orthopedist may be capable of providing high-quality care, the facility at which he or she works may not have the ancillary resources necessary. To ensure optimal care is provided, patients with musculoskeletal injuries should be treated where both the provider and hospital are able to adequately care for a patient's injuries. In the event that a provider feels comfortable managing a given injury but the facility does not have the adequate resources to provide ideal care (in other words, equipment, supplies, staffing, physical therapy, and so on), the patient should be transferred to a facility that does have the capability of providing an optimal level of care.

The variability in provider and institutional capabilities make it difficult to establish uniformly applicable criteria for whom to transfer and whom to manage locally. However, the best interest of the patient should be the underlying principle guiding all transfer decisions. Appendix B is an example of a tool that a trauma center might use to identify who can be cared for locally and who should be transferred to a higher level of trauma care. Using this tool as a template, hospitals can develop institutional protocols and procedures that standardize the decision-making



process for transferring patients with orthopaedic injuries. Implementing such protocols and procedures can help decrease the likelihood of surgeons caring for injured patients at hospitals inadequately equipped to manage certain orthopaedic injuries.

Although hemodynamically stable patients with orthopaedic injuries may benefit from an orthopaedic evaluation prior to transfer, the transfer process should not be significantly delayed to obtain this evaluation. Hemodynamically stable patients with isolated orthopaedic injuries should be evaluated by a qualified orthopaedic provider prior to making the decision to transfer to a trauma center. Again, the decision to transfer should be based upon surgeon and hospital resource availability and guided by the best interests of the patient. Although provider and institutional resources vary across hospitals, examples of orthopaedic trauma patients who could be considered for management at a nontrauma center include:

- Simple fractures without significant soft tissue injury or neurovascular compromise
- Patients without major medical comorbidities

Strong consideration for transfer to a Level I or Level II trauma center should be given to patients with the following orthopaedic injuries:

- Unstable pelvic fracture requiring transfusion of more than six units of red blood cells in six hours

- Complex pelvic or acetabular fractures
- Fracture or dislocation with a loss of distal pulses
- Vertebral fractures or findings concerning for spinal cord injury
- More than two unilateral rib fractures or bilateral rib fractures with pulmonary contusion(s) in the absence of critical care availability

In some situations, patients with minor orthopaedic injuries warrant strong consideration for transfer to a Level I or Level II trauma center.

Examples include patients with:

- Carotid artery, vertebral artery, or other significant vascular injury
- Bilateral pulmonary contusions with a PaO<sub>2</sub>:FiO<sub>2</sub> ratio < 200
- Grade IV or V liver injuries requiring transfusion of more than six units of red blood cells in six hours
- Penetrating injuries or open fracture of the skull
- Glasgow Coma Score (GCS) <14 or lateralizing physical examination findings
- Significant torso injury in the setting of advance comorbid disease, such as coronary artery disease or chronic obstructive pulmonary disease
- Extremes of age, particularly with respect to the pediatric population



To facilitate appropriate and timely management of patients with musculoskeletal injuries, formal transfer arrangements between facilities should be agreed upon. The “Orthopaedic Trauma Worksheet” provided in Appendix B may be helpful in establishing the types of injuries each facility has the optimal resources to manage. Written transfer agreements should clearly specify the expectations of both the transferring and receiving providers, should be mutually agreed upon, and should be frequently reviewed. When deviations from the transfer agreement occur (for example, when an orthopaedic provider is out of town operating room [OR] or computed tomography [CT] scanner at the receiving facility is out of commission), they should be discussed both within and between the involved centers.

Direct, timely communication between orthopaedic providers at each facility prior to patient transfer is ideal and should occur when possible. However, such communication should not delay patient transfer. In all cases where direct communication does not occur, the reasons should be clearly documented by providers on both ends of the transfer. Additionally, imaging studies should never delay transfer of an injured patient; however, if imaging studies are performed, the images and reports should be sent to the receiving hospital with the patient.

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## OPEN FRACTURES

### Key Messages

- Open fractures occur when a fractured bone is exposed to contamination from the external environment through a disruption of the skin and subcutaneous tissues and are susceptible to infection.
- Patients with open fractures should receive intravenous antimicrobials within one hour of presentation to reduce the risk of infection.
  - ▶ Patients with Gustilo open type 1 or 2 fractures should receive a first-generation cephalosporin (for example, cefazolin)
  - ▶ Gram negative coverage should be considered in patients with Gustilo type 3 fractures (for example, gentamicin)
  - ▶ The addition of a penicillin for anaerobic coverage should be considered in the presence of severe contamination or impaired vascularity
  - ▶ In the presence of documented -lactam allergies, consider regimens with a similar spectrum of coverage
- Antibiotics should be administered for no longer than 24 hours after a surgical procedure. In cases of severe contamination, antibiotics may be continued for as long as 72 hours after a surgical procedure.



- Tetanus toxoid should be administered if the patient had an incomplete primary immunization, if it has been >10 years since his or her last booster dose, or if the immunization history is unknown or unclear. Tetanus immunoglobulin should be administered if it has been >10 years since the patient's last booster dose or if he or she has a history of incomplete primary immunization.
- Patients with open fractures should be taken to the operating room for irrigation and debridement within 24 hours of initial presentation whenever possible. Patients with severe fractures associated with gross wound contamination should be brought to the operating room more quickly, and as soon as clinically feasible, based on the patient's condition and resources available.
- Whenever possible, skin defects overlying open fractures should be closed at the time of initial debridement.
- Soft tissue coverage should be completed within seven days of injury for open fractures associated with wounds requiring skin grafting or soft tissue transfers.

Open fractures occur when a fractured bone is exposed through a disruption of the skin and subcutaneous tissues. This type of fracture may occur when the fractured bone itself creates the disruption or when an overlying wound penetrates down to a broken bone. As

a result, the fractured bone is highly susceptible to contamination from the outside environment. These injuries are particularly susceptible to both bone and soft tissue infections, and early management strategies should aim to minimize the risk of such infections. The recommendations provided in this section are for open fractures occurring as a result of blunt force injuries.

When a patient with an open fracture presents to the emergency department, a sterile dressing should be placed over the wound to minimize ongoing wound contamination. It is strongly recommended that patients with open fractures receive broad-spectrum intravenous antibiotics within one hour of presentation. For open fractures with a clean or moderately contaminated wound less than 10 cm in length without extensive soft-tissue damage, flaps, or avulsions (Gustilo type I and II), a first generation cephalosporin (cefazolin) is recommended. For open fractures associated with wounds greater than 10 cm in length, significant contamination, extensive soft tissue damage, or significantly comminuted fractures (Gustilo type III), a first generation cephalosporin and another antimicrobial with gram-negative coverage (for example, gentamicin) is recommended. For open fractures with severe contamination or impaired vascularity, anaerobic coverage should be added (for example, penicillin). In the presence of documented  $\beta$ -lactam allergies, consider regimens with a similar spectrum of coverage.



Scheduled dosing of antibiotics should be continued until surgical management is performed. After the surgical procedure, the duration of antibiotics is dependent on the level of contamination. A minimum of 24 hours of antibiotics should be administered from the start of the surgical procedure. Generally, antimicrobials are discontinued 24 hours after the procedure, but continuation for up to 72 hours may be appropriate for highly contaminated wounds. Antibiotics should not be administered beyond 72 hours unless a second operative intervention occurs within that time period.

In addition to intravenous antibiotics, all patients with open fractures should be evaluated for the potential need for tetanus vaccination. The immunization history of the patient should be obtained, and tetanus toxoid should be administered if the last booster dose was given more than 10 years prior to evaluation or if the vaccination history is unknown or unclear. Tetanus immunoglobulin should also be given when it has been longer than 10 years since the last booster dose or when the patient had an incomplete primary immunization.

Historically, dogma has led orthopaedists to treat open fractures with surgical irrigation and debridement within six hours of the injury or risk increased rates of infection. This practice has come to be known as the “six hour rule” in orthopaedic surgery. However, it has been disproven in recent years by several high quality studies demonstrating that delaying surgical irrigation and

debridement up to 24 hours does not increase infectious complications for open fractures. Based on the best available evidence, the panel does not endorse the “six hour rule.”

Current evidence does, however, demonstrate that the risk of infection increases with increasing fracture severity and time to surgical irrigation and debridement. Widely accepted timing requirements have yet to be established, as the ideal timing of operative intervention likely varies based on a myriad of factors such as mechanism of injury, degree of contamination, amount of vascular disruption, and the immune status of the patient, among others. Taking these issues into consideration, the panel recommends that patients with open fractures should be taken to the operating room for surgical irrigation and debridement within 24 hours of presentation to the emergency department whenever possible. Patients with fractures with gross contamination, should be brought to the operating room more quickly, and as soon as clinically feasible, based on the patient’s condition and resources available.

Skin and/or soft tissue loss frequently complicate the management of open fractures. Open wounds represent a persistent source of potential contamination and therefore infection. It has been demonstrated that increasing times from initial presentation to definitive wound coverage is associated with increased risks of infection. It is recommended that, when possible, skin defects overlying open fractures should be closed at the time of initial





debridement. For open fractures associated with wounds requiring coverage with skin grafting or soft tissue transfers (in other words, Gustilo type III B), it is recommended that coverage be completed within seven days from the time of the injury

*\*This document is specifically addressing open fractures associated with blunt trauma. Management of fractures associated with gunshot wounds is outside the scope of this document.*

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## Damage Control Orthopaedic Surgery

### Key Messages

- Damage control surgery is an integral tool in the armamentarium of the orthopaedic trauma surgeon and should be considered as the first stage of intervention when early definitive surgical management is not possible—typically in patients who are critically injured or those with significant soft tissue injuries pending resuscitation and/or soft tissue injury resolution. More specifically, damage control surgery should be considered in patients who demonstrate:
  - ▶ Severe traumatic brain injury
  - ▶ Inability to be adequately resuscitated as demonstrated by:
    - ▶ Ongoing fluid and blood requirements
    - ▶ High base deficit or lactate, which are not improving
    - ▶ Pulmonary dysfunction requiring significant ventilatory support
  - ▶ Open or closed compromised or suspected compromise of soft tissues (soft tissue loss, significant contamination, severe closed soft tissue injury)
- Damage control surgery should also be considered for patients who receive initial care in an environment with limited experience and/or resources.
- The use of damage control orthopaedic surgery should be monitored by the trauma performance improvement program (PIPS).
- If a patient is in extremis, it is reasonable to place a skeletal traction pin to aid in bony stabilization and alignment. Similarly, patients with femur or pelvis fractures who are not stable enough to be anesthetized for placement of spanning external fixation or are unable to tolerate the additional blood loss or physiologic insult may benefit from a period of skeletal traction.
- Once patients are in the operating room for management of concurrent injuries or able to physiologically tolerate operative intervention, formal stabilization with external or definitive fixation should be performed.

Damage control surgery is utilized for critically ill or injured patients as an early initial step to definitive surgical management. The underlying principle of damage control strategy is to perform only those interventions



needed to preserve life or limb until the patient is resuscitated. This approach implies that early procedures are often truncated, with a view toward staged definitive interventions over the ensuing days. Damage control surgery thus prioritizes resuscitation and correction of metabolic derangements, coagulopathy, hypothermia, and/or resolution of soft tissue injuries over early definitive surgical repair.

In orthopaedic surgery, the focus of damage control surgery is often to control hemorrhage, decrease contamination through debridement, and provide bone and soft tissue stabilization to patients unable to undergo definitive repair. External fixation is often used in damage control orthopaedic surgery, particularly in femur fractures, to minimize ongoing soft tissue damage, decrease risks of fat embolism, control hemorrhage and contamination, alleviate pain due to fracture motion, and facilitate patient mobilization. Additionally, external fixation is used to regain and/or maintain gross length, rotation, and alignment of extremities with unstable fractures and soft tissue injuries that preclude early internal fixation.

After a period of resuscitation, patients are taken back to the operating room for definitive management of their injuries. In general, patients who could benefit from damage control surgery are those undergoing emergent control of life-threatening injuries by other disciplines (for example, trauma surgery, neurosurgery, and so on) or who are reaching the limits of their physiologic reserve as determined by the

presence of hypothermia, coagulopathy, and/or acidosis, or who have severe closed or open soft tissue injuries.

Modern orthopaedic approaches to fractures may in many cases be thought of as a soft-tissue injury that contains within it a fractured bone. Severe compromise of this soft-tissue envelope presents another indication for damage control surgery. Examples of this issue include heavily contaminated open fractures or closed injuries that historically have been shown to do poorly with acute open reduction and internal fixation (ORIF), such as pilon fractures and bicondylar tibial plateau fractures (unicondylar plateau fractures are typically amenable to immediate ORIF). Soft tissue injuries evolve over the hours or days following injury. In this context, temporary approaches to skeletal fixation allow the full extent of the soft tissue injury to declare itself before committing to a definitive internal fixation.

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### Timing of Definitive Repair following Damage Control Surgery

There is considerable variability in the duration and severity of physiologic derangements that occur after trauma. In many cases, these derangements may be short lived and early definitive fracture management may be pursued. In others, definitive management may be significantly delayed. The optimal timing and physiologic targets that indicate it is safe to proceed to definitive management are controversial. Normalization of heart rate and blood pressure are important, but measures of adequate resuscitation, including an



improving base deficit or lactate, might be more accurate to inform decision-making. A retrospective review of traditionally resuscitated patients with an injury severity score (ISS) of >18 and a femur fracture stabilized within 24 hours of admission found that patients with a lactate of >2.5 had a higher pulmonary and infectious complication rate when compared with those with a normal lactate. Additionally, patients with severe traumatic brain injury proceeding to definitive fixation are less likely to have dips in their cerebral perfusion pressure in the operating room if they have been adequately resuscitated. Although there is no clearly identified end point for resuscitation, trauma centers should understand the different markers of resuscitation and choose one or more for evaluating patients within their institution. status can be used to set CPP goals as described above. In a similar fashion, TCD ultrasonography and hemodynamic challenge can also be used to assess autoregulation in TBI patients.

### Long Bone Fractures

Historically, long bone fractures were acutely managed with traction due to a perceived increased risk of fat embolization syndrome (FES) in the time immediately following injury. However, several decades of research have demonstrated the benefits of early stabilization of long bone fractures with no increased risk of FES or their sequelae. For example, in one retrospective study, 22 percent of patients treated with delayed stabilization developed FES compared with only 5 percent treated

with early stabilization. In another study, it was demonstrated that polytrauma patients with long bone fractures treated with early mechanical ventilation and early fracture stabilization had a decrease in the incidence of acute respiratory distress syndrome (ARDS) and decreased mortality rate for the most severely injured patients with an ISS >50. A randomized controlled trial comparing femoral shaft fractures stabilized less than 24 hours after injury with those stabilized after 48 hours found that early fixation in patients with an ISS >18 decreased the incidence of pulmonary complications (ARDS, FES, pneumonia), intensive care unit (ICU) length of stay, and hospital length of stay.

Based on current evidence, long bone fractures should be stabilized early in multiply injured patients. The method for doing so depends on whether a damage control approach is required. If the patient presents with isolated injuries and there is no indication for damage control surgery (resuscitated patient, no severe traumatic brain injury (TBI), adequate soft tissue envelope), then early definitive stabilization is appropriate. For these patients, earlier stabilization simply leads to a decreased length of hospital stay and a lower risk of complications related to immobilization. However, for patients in extremis or those in whom resuscitation is incomplete, alternatives to definitive fixation need to be considered, most commonly external fixation.



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## Patients with Thoracic Injuries and a Femoral Shaft Fracture

This injury pattern was the initial focus of damage control orthopaedics, with the concern being significant worsening of pulmonary dysfunction due to FES. If the patient has been adequately resuscitated and meets no other indication to hold off on definitive fixation, there appears to be little risk to proceeding. The exception might be patients who at or shortly following presentation have evidence of significant pulmonary dysfunction on high levels of ventilatory support who could not tolerate any nonessential operative procedure. Temporary external fixation might be reasonable in this scenario.

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## Patients with Concurrent Severe Traumatic Brain Injury

Special consideration should be given to patients with concomitant orthopaedic and TBI. The management of fractures in patients with TBI represent a particular challenge in that early surgical fixation may complicate the acute management of TBI. The goals of acute TBI management are to maintain adequate cerebral perfusion, prevent hypotension, provide adequate oxygenation, avoid hypo- and hypercarbia, and maintain normothermia. Efforts should be made to adhere to each of these goals. Intraoperative monitoring of intracranial pressure (ICP) should be considered to support cerebral perfusion pressure. In the context of a stable ICP and mean arterial pressure (MAP), definitive fixation can be considered in the resuscitated patient, as these patients are less apt

to experience transient episodes of hypotension in the operating room. The under-resuscitated patient or those patients whose ICP and cerebral perfusion pressure (CPP) have not yet stabilized are best served with damage control procedures or traction.

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## Damage Control and Performance Improvement

Although damage control interventions in orthopaedic surgery are necessary at times, delay of definitive fixation leads to higher rates of skin breakdown, prolonged hospital length of stay, increased pain, decreased patient satisfaction, and delays to rehabilitation. The utilization of damage control orthopaedic surgery and subsequent complications should be monitored through the performance improvement process. Similarly, failure to employ a damage control approach to orthopaedic injuries where it is indicated could result in severe physiologic insult and even amputation (in an otherwise salvageable extremity) or death.

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# THE MANGLED EXTREMITY

### Key messages:

- A mangled extremity has an injury to three of the four major components of a limb: soft tissues, nerves, vascular supply, and skeletal structures.
- If the patient has inadequate physiologic reserve due to associated other injuries, or the



mangled extremity is contributing to significant physiologic derangement, attempts at limb salvage should not be considered: life takes precedence over limb.

- Limb salvage should be attempted only when there is a reasonable expectation that the limb is salvageable.
- Surgical decision making should take patient- and injury-specific factors into consideration
  - Age, comorbidity, functional status, occupation, patient preference, and self-efficacy/ social support systems are important patient factors.
  - The extent of soft tissue injury, fracture pattern, level of the vascular injury, warm ischemia time, the anatomic status of nerves (in other words, transection versus continuity injury), and the status of the ipsilateral foot (for lower extremity injuries) are important injury specific factors.
- Limb salvage and amputation are both associated with significant morbidity, but overall functional outcomes and quality of life are similar.
- Decision to undergo multiple operations for limb salvage is often a multidisciplinary process and should be considered in conjunction with other providers (orthopaedics, vascular, plastics, and trauma) along with strong patient engagement.

The mangled extremity presents a unique set of challenges to orthopaedic surgeons. The goals of this section are to summarize the important considerations in the decision-making process when weighing the risks and benefits of limb salvage versus amputation, and to outline what patients might expect with either approach.

A mangled extremity is a limb with an injury to three of the four systems within the extremity. These systems include: (1) soft tissues (muscle, fascia, and skin), (2) nerves, (3) vascular supply, and (4) skeletal structures. The involvement of multiple functional systems within a limb makes the mangled extremity a particularly severe orthopaedic injury. Most importantly, these injuries are not simply “open fractures.”

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### Assessment of the Mangled Extremity

Patient- and injury-specific factors need to be considered when assessing the mangled extremity. Patient’s age, comorbidities (for example, diabetes), occupation, and preferences all factor into decision making. Associated injuries and the presence of shock are also important considerations. There needs to be a full evaluation of the extremity, including the fracture pattern, level of the vascular injury, warm ischemia time, the anatomic status of nerves to ensure that deficits are not related to a neuropraxia, and the status of the ipsilateral foot (for lower-extremity injuries). If time allows, early assessment should be multidisciplinary so that priorities are managed in a manner that preserves



life over limb and then maximizes functional potential of the extremity.

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## Limb Salvage

Limb salvage should be attempted only when there is an expectation that the extremity is salvageable, though often times an absolute indication for limb salvage versus amputation is not present. The decision to proceed with attempted limb salvage requires that the patient has adequate physiologic reserve to tolerate the necessary surgical procedures. Patients who are persistently hemodynamically unstable, acidotic, coagulopathic, or in extremis are not appropriate candidates for attempts at limb salvage. This fact is particularly true when the mangled extremity is a contributing component to the patient's clinical condition.

Delayed amputation following attempted limb salvage is not without consequence. One potential issue is that during the limb salvage process patients become particularly invested in the management of their injured limb, making it more difficult for them to consider delayed amputation when salvage attempts are unsuccessful. Failed limb salvage is often associated with numerous hospitalizations, surgical procedures, infectious complications, nonunion, and might ultimately still end in amputation. Additionally, there might be significant social, economic, and psychological consequences, making it important to consider the longer impact on the patient when all efforts are being expended to preserve the limb. Maximizing functional

outcome and quality of life should be the goal rather than preservation of a dysfunctional extremity.

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## Amputation

There is limited evidence in the literature regarding absolute indications for amputation in the context of the mangled extremity. As a result, there are few well-defined, objective criteria for amputation. Higher energy injuries and presentation with shock increase the probability of amputation but are contributing factors to decision-making rather than absolute indications. Common indications for amputation include total or "near total" amputations, warm ischemia time > six hours, complete anatomic sciatic or tibial nerve transection, and/or loss of plantar skin and soft tissues. Inability to re-vascularize an extremity (and unsuccessful attempts at re-vascularization) is also predictive of failed limb salvage and the ultimate need for amputation. Evidence suggests there is a hierarchy of injuries that influence decision-making where soft tissue > nerve > bone > artery, emphasizing the importance of soft tissues in the preservation of the mangled extremity. It is important to note that most patients will not have an absolute indication for an amputation but will fall into an indeterminate grey zone.

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## Which Has Better Civilian Patient Outcomes, Limb Salvage or Amputation?

Patients often want to know which treatment strategy will provide them with better outcomes, limb salvage or



amputation. This is a difficult question to answer due to injury heterogeneity, variability in patient goals/preferences, and conflicting results in the literature. Therefore, this decision becomes a very individualized one that must take into account many patient, social, surgical, and injury-specific factors. Longitudinal analyses suggest both choices have significant morbidity and that overall functional outcomes for both approaches are equivalent. However, salvage attempts require more surgical procedures (with associated complications) and lengthier rehabilitation than early amputation. Chronic pain, particularly with prolonged standing, can be a significant issue for patients following limb salvage. However, approximately 50 percent of patients undergoing amputation experience phantom limb pain. Amputees, however, are more frequently required to change occupations, while many salvage patients can eventually return to their previous line of work.

The decision making regarding pursuing limb salvage or early amputation is often a team decision. Although plastic surgery, vascular surgery, trauma surgery, or other specialty services may contribute to the care of a mangled extremity, treating orthopaedic surgeons should discuss the treatment options with the patient and the patient's family, as patient preference may ultimately have the greatest role in the decision-making process

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## COMPARTMENT SYNDROME

### Key Messages

- A high index of suspicion for compartment syndrome should be maintained for all patients with extremity injuries.
- Compartment syndrome can result in irreversible tissue damage within six hours of impaired perfusion.
  - Caution regarding the estimation of elapsed time is important, as the time of precise onset is often uncertain.
- Compartment syndrome is a dynamic process and, in patients with high-risk injuries, an evaluation should occur every one to two hours for a 24 to 48 hour period.
  - Sequential physical examinations should be performed for individuals at risk for compartment syndrome, as a single exam at one point in time is unreliable.
- The most reliable early clinical findings of compartment syndrome are:
  - Pain out of proportion to the injury (in other words, pain that is initially well controlled and then becomes refractory to and/or requires escalating doses of analgesics



- ▶ Pain with passive stretch of the musculature within the involved compartment
- ▶ Paraesthesias of the nerve(s) running through the compartment(s)
- Clinical findings are very reliable in ruling out acute compartment syndrome.
- Patients with an unreliable or unobtainable clinical exam may benefit from measurement of intracompartmental pressures. A gradient of <math><30\text{ mmHg}</math> between the diastolic blood pressure and intracompartmental pressure is predictive of patients who would benefit from a fasciotomy.
- When a compartment syndrome is suspected, early fasciotomies should be performed using long, generous skin and fascial incisions to release all the compartments of the involved limb, and those incisions should be left open at the conclusion of the procedure.

Compartment syndrome is a true orthopaedic surgical emergency. Although compartment syndrome is most common in the leg and the forearm, it can occur in any fascial compartment of the extremities, including the hand, forearm, upper arm, deltoid, buttocks, thigh, calf, and foot. Following the onset of impaired perfusion, microscopic findings of tissue compromise can be seen in as little as two hours. Changes resulting in clinical symptoms can occur within two to four hours, and irreversible changes in nerve

tissue and skeletal muscle can be seen in as little as six hours. Delays in treatment, even if only for several hours, can result in severe and irreversible morbidity that may ultimately necessitate amputation. Early fasciotomy has been shown to be associated with improved outcomes and should be performed emergently when a compartment syndrome is suspected.

Compartment syndrome results in tissue ischemia that worsens with passing time and/or increasing intracompartmental pressure. It is also important to consider that damaged tissue is more vulnerable to increases in intracompartmental pressure. Higher pressures result in rapid progressive ischemia, whereas lower pressures result in slower, but still progressive, ischemia. For this reason, a single “normal” compartment assessment is unreliable, and multiple repeat evaluations should be performed every one to two hours for a minimum of 24 to 48 hours or as clinically warranted.

In the setting of orthopaedic trauma, it is essential to maintain a high index of suspicion for the development of a compartment syndrome. All high-energy injuries warrant consideration of compartment syndrome. A detailed history regarding the mechanism of the injury, a thorough physical exam specifically evaluating for compartment syndrome, and radiographic studies assessing the extent of bony injuries (which may be indicative of the magnitude of energy absorbed by the limb) are key. Most compartment syndromes occur in the calf or forearm. In patients with associated vascular injuries, the development of a





compartment syndrome should be presumed until proven otherwise.

It is important to note that not all compartment syndromes are the result of high-energy or associated vascular injuries. Compartment syndrome can occur after relatively minor injuries to an extremity, even in the absence of fracture. This reality emphasizes the need to maintain a high index of suspicion for all patients presenting with extremity injuries. Additionally, compartment syndrome can develop in the setting of hemorrhage into an extremity compartment. Patients who take anticoagulants, who have long periods of leg elevation, and those who have been “found down” after a prolonged period of time are also at an increased risk for developing compartment syndrome.

In a patient that is awake with a normal sensorium, the diagnosis of compartment syndrome is best made by physical examination. Classically, the development of compartment syndrome is marked by a constellation of clinical findings, which are often referred to as the “P’s” of compartment syndrome. Paraesthesias, pain out of proportion to injury, and pain with passive stretch are reliable early physical exam findings of compartment syndrome. Typically, pain is the earliest and most pronounced clinical finding. Specifically, worsening pain or pain that becomes refractory to medication is particularly concerning for the development of compartment syndrome and warrants further examination. In some patients, pain may be difficult to assess. In these patients, paraesthesias may be the first detectable

physical exam finding. It is important to remember that paralysis, pallor, and pulselessness are typically very late findings of compartment syndrome and might never be present. Although the degree of “tightness” or “fullness” of the compartment on physical examination is often used to assess patients with an equivocal exam, this symptom has been shown to have low diagnostic sensitivity and specificity, even in the hands of experienced clinicians. Overall, clinical findings have been shown to have a low sensitivity and positive predictive value. However, when more than two clinical findings are present, the sensitivity and positive predictive value improve. While making the diagnosis based on clinical exam might be insensitive, a negative physical exam without a tense compartment is very helpful to rule out compartment syndrome.

In the appropriate clinical context (for example, extremity injury with soft tissue swelling and/or concerning signs or symptoms), the diagnosis of compartment syndrome should be made by physical exam. In patients with suspected compartment syndrome but an unreliable or unobtainable clinical exam (for example, unconsciousness, altered sensorium, distracting injuries, pediatric patients), measuring intracompartmental pressures can be helpful. Historically, absolute pressures from 30 to 45 mm Hg were considered diagnostic of compartment syndrome. However, tissue perfusion is determined by the arteriovenous pressure gradient, which is dependent upon a patient’s arterial blood pressure. Due to the variability in blood



pressure between patients, the use of an absolute intracompartmental pressure is not recommended. Instead, compartment syndrome should be diagnosed when the difference between a patient's diastolic blood pressure and compartment pressure ( $\Delta P$ ) is less than 30 mm Hg. When  $\Delta P$  is less than 30 mm Hg, fasciotomy should be performed. This diagnostic approach has demonstrated very low rates of a missed compartment syndrome and is recommended when taking adjunctive measurements to supplement an equivocal clinical exam. Where continuous compartmental pressure monitoring is possible, a  $\Delta P$  less than 30 mmHg for two hours is very sensitive for acute compartment syndrome.

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## MANAGEMENT OF PELVIC FRACTURES WITH ASSOCIATED HEMORRHAGE

### Key Messages

- Hemodynamically stable patients with pelvic fractures should undergo cross-sectional imaging to evaluate the extent of the injury and for the presence of pelvic hemorrhage.
- Patients with evidence of contrast extravasation on imaging and either significant hemorrhage or hemodynamic instability should undergo formal angiography and potential angioembolization.

- Hemodynamically unstable patients with pelvic fractures should have a pelvic binder or circumferential sheet used to temporarily stabilize their pelvis.
- Early activation of a massive transfusion protocol should be strongly considered.
- When angiography is unavailable, preperitoneal packing and/or external fixation of the pelvis should be performed. If this step is not possible, early transfer to a designated trauma center is recommended.
- Selective embolization is preferred over nonselective embolization, when possible, due to a lower risk of complications.
- Patients with pelvic fractures are at high risk for deep vein thrombosis (DVT) and pulmonary embolism (PE). Early initiation of pharmacologic DVT prophylaxis is recommended.

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### Initial Evaluation and Diagnosis

#### Hemodynamically Stable Patients

Following the primary and secondary surveys, hemodynamically stable patients with evidence of a pelvic fracture on X ray should undergo cross-sectional imaging with a CT scan for further evaluation. Prior to being taken to CT, these patients should be placed in a temporary pelvic binder for injury patterns at high risk for bleeding, such as open book and vertical shear patterns. CT with correct timing of intravenous contrast (CT-angiography) provides important



information relevant to the type of pelvic ring injury and source and extent of hemorrhage. The presence of contrast blush on CTA is predictive of a potential need for angiobolization. Early consultation of a team with angiographic capabilities is recommended.

In the absence of CT evidence of active extravasation, signs of ongoing pelvic hemorrhage such as hypotension, tachycardia, increasing base deficit, or decreasing hemoglobin may also be indications for formal angiographic evaluation. In this scenario, bleeding may not have been evident at initial evaluation due to hypovolemia or vasospasm. With resuscitation, bleeding may become apparent. Additional factors such as anti-coagulant or anti-platelet therapy may lower the threshold for pursuing angiography.

Angiographic evaluation should include selective bilateral hypogastric artery angiograms, with treatment of active extravasation, pseudoaneurysms, tapering of vessels, or vessel irregularity in the area of injury

### **Hemodynamically Unstable Patients**

When patients are hemodynamically unstable as a result of hemorrhage, a massive transfusion protocol should be activated. While initiating resuscitative efforts in hemodynamically unstable patients with pelvic fractures, a temporary pelvic binder or circumferential sheet should be positioned around the greater trochanters. Additionally, a rapid and thorough assessment to exclude other sources of potential hemorrhage is required before assuming that pelvic-

fracture related bleeding is responsible. This can be accomplished through portable X rays of the chest and pelvis. To rule out intraabdominal hemorrhage, a Focused Assessment with Sonography in Trauma (FAST) scan or diagnostic peritoneal aspiration (DPA) should be performed. If intraabdominal hemorrhage is diagnosed, hemodynamically unstable patients should be taken to the operating room for exploration and should be considered for pelvic fracture external fixation.

If intraabdominal hemorrhage is not diagnosed by FAST scan or DPA, patients should undergo pelvic stabilization with either a temporary pelvic binder or sheet followed by surgical stabilization and preperitoneal packing. Stability provided by an external fixator provides greater support for pre-peritoneal packs and thus if time allows, there is better control of hemorrhage if fixation is achieved prior to packing. Patients who remain hemodynamically unstable following pelvic stabilization and those with preperitoneal packing in place should undergo angiography and potential embolization.

For patients in extremis solely from pelvic bleeding, several options are available depending on hospital resources. Although the treatment algorithm is similar to the algorithm mentioned previously, for patients truly in extremis, a potential alternative initial intervention is Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA). Early experience with REBOA in lieu of or in addition to preperitoneal packing has shown promising results.



In centers that do not have angiography availability 24/7 and where procedure such as preperitoneal packing and REBOA are rarely performed, hemodynamically unstable patients with pelvic fractures should be promptly transferred to a higher level of care following placement of pelvic binder and initiation of resuscitation.

### **Role of External Fixation**

Reducing pelvic volume and minimizing movement of fractured segments of the pelvis are critical for patients with active pelvic bleeding. Therefore, early pelvic stabilization with a temporary pelvic binder, a sheet, or an external fixator is recommended. Temporary stabilization is especially important for open book/ anterior compression, vertical shear, or combined fracture types, as significant bleeding occurs with sacroiliac joint and pubic symphyseal disruption. Additionally, temporary stabilization via external fixation is important to achieving successful preperitoneal packing, as it maintains a stable pelvis against which to place hemorrhage-controlling packing. The main goals of the external fixator are to reduce pelvic motion to allow stabilization of the pelvic hematoma, to reduce the risk of further bleeding from osseous motion/ damage, and to reduce the pelvic volume. Several methods of external fixation are available and should be performed by the orthopaedic surgeon. Due to the reported complications, use of a pelvic “C” type clamp is discouraged. A pelvic binder should be used. Definitive stabilization should be performed as early as other injuries and the patient’s physiology allow.

### **Complications**

Complications of pelvic embolization are rare, but include gluteal or rectal necrosis, wound infections, nonhealing, and re-bleeding. To minimize these complications, selective embolization of hypogastric artery branches is preferred over nonselective proximal embolization. However, in situations of severe hypotension with active extravasation of one or more hypogastric branches, rapid proximal embolization is warranted and may be life-saving.

### **DVT Prophylaxis in Pelvic Fracture Patients**

Among patients with pelvic fractures, up to 34 percent develop proximal DVTs and up to 12 percent go on to have pulmonary embolism. Pharmacologic DVT prophylaxis with either low-molecular weight heparin or low-dose heparin should be initiated as quickly as possible, as it has been shown to prevent the formation of DVT. If immediate pharmacologic prophylaxis is contraindicated, bilateral lower extremity pneumatic compression devices should be considered as the injury pattern allows. There is no high quality evidence regarding preferred timing or agent for DVT prophylaxis in patients with pelvic fractures. It is reasonable to start pharmacologic prophylaxis once bleeding has ceased as defined by lack of ongoing transfusion and stabilization of hemoglobin. This theory is supported by a study of 100 patients who received low-molecular-weight heparin within 24 hours of admission (hemodynamically stable patients) or upon establishing hemodynamic stability (patients not hemodynamically



stable within the first 24 hours of admission) who demonstrated a lower incidence of DVT compared with patients with delayed initiation of pharmacologic DVT prophylaxis.

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## GERIATRIC HIP FRACTURES

### Key Messages

- Hip fractures are common among the elderly, are associated with substantial morbidity and mortality, and result in a significant cost to the health care system.
- Early consultation with medical or geriatric specialists is recommended for geriatric hip fracture patients with significant medical co-morbidities.
- Peri-operative regional anesthesia reduces pain and might reduce delirium and cardiac events in the postoperative period.
- Timely surgical intervention within 48 hours for hip fractures is recommended. If appropriate resources are available at the admitting hospital, it is not necessary to transfer isolated hip fractures to a designated trauma center.
- Surgical reduction and fixation or reconstruction are the primary treatment options for geriatric hip fractures.
- Multimodal analgesia, venous thromboembolism (VTE) prophylaxis, delirium prevention/management, nutritional supplementation,

osteoporosis screening, and early physiotherapy and rehabilitation are important components of postoperative care following hip fracture surgery in the elderly.

Fractures of the proximal femur, or hip fractures, are common injuries in the elderly. Typically, this injury is the result of relatively “low energy” mechanisms of injury such as falls from standing height. The elderly patient population is particularly susceptible to hip fractures due to the increased prevalence of osteoporosis and medical co-morbidities that predispose them to falls. Furthermore, when these injuries do occur, elderly patients are at an increased risk of experiencing complications from their injuries and prolonged hospitalization or readmission. The extent of advanced age, comorbidities, frailty, and complications of hospitalization conspire such that almost 30 percent of patients die within one year of injury.

In response to the significant burden of hip fractures in the elderly, the American Academy of Orthopaedic Surgeons (AAOS) published clinical practice guidelines in 2014 entitled “Management of Hip Fractures in the Elderly,” which are solely dedicated to the care of geriatric patients with hip fractures ([aaos.org/research/guidelines/GuidelineHipFracture.asp](http://aaos.org/research/guidelines/GuidelineHipFracture.asp)). Through multidisciplinary collaboration, these guidelines provide a detailed overview of the optimal practices regarding the pre-, intra-, and postoperative management of hip fractures in the elderly. Many of the recommendations included in this section are detailed in the full AAOS clinical practice guideline document.



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## Injury Assessment and Medical Optimization

When a geriatric patient presents with severe hip pain, particularly following a fall, a hip fracture should be suspected. Under such circumstances, a thorough history and physical examination should be performed, with particular attention given to the evaluation for concurrent injuries. Additionally, in the presence of significant medical comorbidities outside of the management expertise of the orthopaedic surgeon, early consultation with an inpatient medical or geriatric specialist may be beneficial, as they can help manage and medically optimize injured geriatric patients. Additionally, geriatric specialists or hospitalists may help streamline preoperative testing and serve as an effective liaison to the anesthesia team. Given the unique challenges in providing care to the injured elderly, a well-coordinated and multidisciplinary approach to the initial management of geriatric hip fractures is encouraged.

The diagnosis of a hip fracture is typically evident on standard radiographic assessment of the affected hip. When a hip fracture is suspected in the setting of normal radiographs, it is recommended that additional imaging (for example, MRI) be obtained to evaluate for the presence of a nondisplaced fracture. Once diagnosed with a hip fracture, these patients are typically admitted to the hospital, medically optimized, and should be surgically treated as soon as able, preferably within 48 hours. There is strong evidence that regional anesthesia improves perioperative

management in patients with hip fracture and may reduce postoperative delirium and cardiac events.

Geriatric fractures of the proximal femur broadly fall into three categories: femoral neck fractures, intertrochanteric fractures, and subtrochanteric fractures. The different methods of surgical treatment are detailed in subsequent portions of this document.

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## Operative Care

The volume of geriatric hip fractures in need of timely surgical intervention is substantial. In general, operative management of geriatric hip fracture is an urgent rather than emergent priority at most centers. The volume of emergent surgical cases at designated trauma centers has the potential to, at times, compromise timely surgical repair of geriatric hip fractures. In fact, managing these patients locally may facilitate timely surgical intervention and ultimately provide the patient with the high quality of care available in the local community.

Surgical reduction and internal fixation or reconstruction are the primary treatment options for geriatric hip fractures.

While there is a general agreement that operative management of hip fractures is appropriate, there is variability in opinions regarding specific treatment options in different clinical situations. A summary of current recommendations for optimal surgical management based on specific injury patterns and patient factors is listed in Table 1. A detailed discussion of these recommendations is provided in the AAOS “Management of Hip Fractures in the Elderly” evidence-based clinical practice guidelines.



**Table 1. Geriatric Hip Fracture Fixation Options.**

	<b>Healthy/Community Ambulator</b>	<b>Multiple Medical Co-Morbidities/ Limited Ambulator</b>
<b>Undisplaced Femoral Neck Fracture</b>	Fixation	Fixation
<b>Displaced Femoral Neck Fracture</b>	Hemiarthroplasty or Fixation	Hemiarthroplasty or Fixation
<b>Stable Intertrochanteric Fracture</b>	Sliding Hip Screw or Cephalomedullary Nail	Sliding Hip Screw or Cephalomedullary Nail
<b>Unstable Intertrochanteric Fracture</b>	Cephalomedullary Nail	Cephalomedullary Nail
<b>Reverse Obliquity/ Subtrochanteric Fracture</b>	Cephalomedullary Nail	Cephalomedullary Nail

Anesthesia is an essential component of the operative management of geriatric hip fractures. The best evidence currently available suggests similar clinical outcomes for patients undergoing general or spinal anesthesia for hip fracture surgery. As a result, one modality is not recommended over the other and patient-specific factors and preferences should be considered. It may be beneficial for individual hospitals to standardize the approach to anesthesia for geriatric hip fractures in order to streamline care.

For patients with unstable femoral neck fractures, strong evidence supports the use of arthroplasty for managing

these injuries. Unipolar and bipolar hemiarthroplasty for these fractures have similar outcomes. However, the use of a bipolar component may be associated with higher implant cost, making the routine use of bipolar hemiarthroplasty as a reconstructive option for geriatric hip fractures potentially less cost effective.

For patients with unstable intertrochanteric fractures, subtrochanteric fractures, or reverse obliquity fractures, use of a cephalomedullary device is recommended. In rare cases, proximal femoral replacement may be indicated.



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## Postoperative Recovery and Rehabilitation

Similar to the initial assessment and medical optimization of geriatric hip fracture patients, the postoperative recovery and rehabilitation process should involve a multidisciplinary team of health care providers, including orthopaedists, medical or geriatric specialists, and rehabilitation specialists. The goal of the recovery and rehabilitation process is to achieve a safe, timely, and maximal restoration of functional status.

The early postoperative period should include any necessary resuscitation, optimal analgesia, and venous thromboembolism (VTE) prophylaxis. It is recommended that the blood transfusion threshold for postoperative resuscitation of asymptomatic hip fracture patients is no higher than 8 g/dl. Additionally, the use of multimodal pain management after hip fracture surgery is recommended based on a strong body of supporting evidence. Multimodal pain management may consist of a combination of NSAIDs, acetaminophen, narcotic analgesics, neurostimulation, local or regional anesthetics, epidural anesthetics, and/or relaxation techniques.

With respect to VTE prophylaxis, there is moderate evidence supporting the use of pharmacologic prophylaxis in the postoperative period, although there is no single regimen that is preferred.

Postoperative delirium prevention is also important to providing optimal postoperative care. Postoperative delirium can significantly complicate the postoperative course for elderly

hip fracture patients. To help prevent delirium, it is recommended that optimal analgesia is achieved through nonopioid medications whenever possible. Additionally, medications that risk inducing delirium should be avoided. When delirium does occur, it is strongly recommended that benzodiazepines be avoided as a first-line treatment strategy, unless specifically indicated. Detailed information regarding the recommended preventative and treatment strategies for postoperative delirium in the elderly are provided in the American Geriatrics Society (AGS) "Clinical Practice Guideline for Postoperative Delirium in Older Adults" and in the ACS TQIP guidelines on management of the elderly trauma patient.

Nutritional supplementation is also beneficial for geriatric hip fracture patients, as evidence supports that postoperative nutritional supplementation reduces mortality and improves nutritional status. Similarly, providing supplemental vitamin D and calcium to patients following hip fracture is also recommended.

Patients should be evaluated for osteoporosis with a view toward intervention where appropriate. There is moderate evidence that a means of evaluating and managing osteoporosis in this population might reduce mortality and the rate of subsequent fractures.

Perhaps one of the most important components of the postoperative care of the elderly is rehabilitation. The rehabilitation process should be initiated upon hospital admission and continue through discharge. It is recommended that both occupational and physical





therapy be provided throughout the hospitalization and following discharge. Intensive postdischarge physical therapy is also recommended, as it has been shown to be associated with improved functional outcomes.

## MANAGEMENT OF PEDIATRIC SUPRACONDYLAR HUMERUS FRACTURES

### Key Messages

- A supracondylar distal humerus fracture or a suspected supracondylar fracture in a skeletally immature patient warrants evaluation by an orthopaedic surgeon.
- There should be a low index of suspicion for concomitant nerve injuries, vascular injuries, and ipsilateral distal radius fractures in a child with a supracondylar fracture of the humerus.
- Nonoperative and operative management may be used for the appropriate fractures.
- When there is vascular compromise to the distal upper extremity, immediate closed reduction is indicated.
  - Failure to reperfuse the hand after a closed reduction in the operating room suggests a need for open exploration of the vessel in the antecubital fossa.

Supracondylar fractures of the humerus are common pediatric injuries, accounting for more than half of all pediatric elbow fractures. These fractures most commonly occur in children ages five to seven years old, with a similar frequency in males and females. Supracondylar humerus fractures are typically a result of an extension injury, most often a fall on an outstretched hand. Neuropraxias, vascular injuries, and/or an ipsilateral distal radius fracture are of particular concern in supracondylar humerus fractures, and all patients with these fractures should be evaluated for these concomitant injuries. Failing to appropriately manage these injuries can result in significant complications, including vascular compromise with subsequent loss of neurological function, muscular function, and/or improper bone growth.

When evaluating patients with potential supracondylar humerus fractures, a thorough physical exam is required, including a thorough evaluation for any neurological, vascular, and other osseous abnormalities. Any radiographic evidence of a supracondylar fracture, including the presence of a “posterior fat pad sign,” should prompt evaluation by an orthopaedic surgeon.

In 2011, the American Academy of Orthopaedic Surgeons (AAOS) published clinical practice guidelines entitled “Guideline on the Treatment of Pediatric Supracondylar Humerus Fractures.” Many of the recommendations included in this section are detailed in the full AAOS clinical practice guideline document.



Patients with displaced supracondylar humerus fractures (Gartland Type II or III and displaced flexion type fractures) without neurologic or vascular compromise should be considered for closed or open reduction followed by pin fixation in the operating room. For these fractures, closed reduction is typically attempted first. When closed reduction is unsuccessful, open reduction should be performed. Nonoperative management of these types of displaced supracondylar humerus fractures is not recommended. Recommendations regarding the optimal timing of surgery have not been clearly defined. However, treatment within 12 to 18 hours of the injury for Gartland Type III fractures is recommended.

All patients with supracondylar humerus fractures with evidence of decreased perfusion to the hand should undergo an immediate emergent closed reduction of the fracture. When signs of compromised perfusion to the hand persist following a closed reduction and pinning of the fracture in the operating room, urgent operative exploration of the vessel in the antecubital fossa is recommended. When pulses in the wrist remain absent following reduction but the hand is well perfused (for example, the hand is pink and warm on examination), the decision to explore the antecubital fossa should be made on a case-by-case basis.

There is not strong enough evidence to support specific recommendations for the optimal management approach for patients with nerve injuries as a result of a supracondylar fracture. These patients are often challenging to manage, particularly in the acute setting when a lack of normal sensation raises concern

for being able to monitor patients for the development of muscle ischemia since they cannot be monitored for the development of numbness and/or increasing pain. While evidence is limited, strong consideration should be given to rapidly taking these patients to the operating room given the challenges in following their clinical exam for evidence of progressive muscle ischemia. Recommendations regarding the indications/timing for electro diagnostic studies and nerve exploration cannot be made given currently available evidence. As a result, the diagnostic and management of these nerve injuries should be handled on an individual basis.

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## REHABILITATION OF THE MULTISYSTEM TRAUMA PATIENT

### Key Messages

- A multidisciplinary rehabilitation team can provide optimal care to multiply-injured patients and should be integrated into the acute care hospitalization.
- Initial evaluation by a rehabilitation team should occur as early as possible following admission, even for critically ill patients unable to actively participate.
  - Early evaluation provides an opportunity for the development of a proactive rehabilitation program and might reduce functional decline during hospitalization.



- Effective communication is key for an efficient, well-functioning rehabilitation team to optimize the functional outcomes of injured patients.

Rehabilitation is a vitally important component of trauma care, particularly in the setting of orthopaedic injuries that result in an acute decline in functional status. The rehabilitation process should begin as soon as possible following admission and should involve multidisciplinary collaboration. Although the specific rehabilitation needs of individual patients will ultimately determine the members of their multidisciplinary rehabilitation team, team members may include the trauma team, other surgical teams, medical consultants, rehabilitation physicians (physiatrists), physical therapists, occupational therapists, speech and language pathologists, neuropsychologists, medical social workers, nurses, and discharge planners. The expertise of these individuals facilitates the optimal care of injured patients.

Assessment by the rehabilitation team should occur as early as possible, ideally within the first 48 hours of admission. The presence of concomitant injuries complicates rehabilitation efforts of orthopaedic injuries, particularly when they might prevent patients from early participation in rehabilitation. However, this fact does not preclude the initiation of the rehabilitation process, as even intubated, critically ill patients can be evaluated for baseline functional status, co-morbidities that may impact their rehabilitation course, specific needs for

their in-hospital rehabilitation, and for anticipated posthospital disposition needs. Additionally, the early evaluation of such patients can facilitate the development of a rehabilitation plan that can be implemented as soon as the patient is able to participate and thus avoid delays in rehabilitation.

Following the initial evaluation by the rehabilitation team, the role of the team varies based on the clinical condition of the patient. When patients are unable to participate in physical or occupational therapy, the rehabilitation team can provide valuable guidance in making recommendations on bed positioning, splinting/bracing, and passive range of motion exercises. These actions alone can help prevent skin breakdown, contractures, and other sequelae of prolonged immobility. Members of the rehabilitation team can also provide assistance managing pain, spasticity, nerve injuries, and agitation.

When patients are able to actively participate in therapy, the focus of the rehabilitation process typically focuses on improving mobility, gait, and activities of daily living through physical and occupational therapy. While the therapists focus on the active rehabilitation process, the other members of the team typically make preparations for discharge. This step often includes determining discharge disposition, arranging for postdischarge therapy, and obtaining any necessary supplies or equipment a patient may need after discharge. Effective planning includes evaluating the patient's social support network, addressing challenges within the home, having an



understanding of activity restrictions, and acknowledging potential equipment needs. Given the multidisciplinary nature of the rehabilitation process following trauma, communication is essential. Representatives from the trauma and rehabilitation teams should meet regularly to discuss the care plans for every patient. This step can be achieved through formal integration into ward rounds or through regularly scheduled interdisciplinary care meetings. Additionally, identifying a single representative or leader from each specialty represented on the rehabilitation team can help optimize communication and facilitate smooth transitions of care regarding the rehabilitation process.

An effectively functioning multidisciplinary rehabilitation team can be an integral component of providing optimal care to the injured patient. Early involvement of the rehabilitation team and effective communication are important and can help to optimize the surgical, medical, and functional outcomes of the multisystem trauma patient.

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## APPENDIX A: PERFORMANCE IMPROVEMENT INDICATORS

A list of suggested performance improvement (PI) indicators for hospitals with a particular interest in improving the quality of orthopaedic trauma care is provided here. Using

these indicators is not a requirement for verification, but they might serve as useful tools for process improvement and reflect a combination of evidence and expert opinion. Longitudinally tracking each of these metrics within a hospital can provide valuable insight into institutional practice patterns and potential opportunities for improvement.

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### Triage and Transfer of Orthopaedic Injuries

- All patients with orthopaedic injuries are transferred to a higher level of care when the resources to optimally manage the orthopaedic injury or concomitant injuries exceed those available at the evaluating hospital.
- The transfer of all patients with orthopaedic injuries to a higher level of care is conducted in a timely (as defined by institutional protocol) manner.
- All deviations from predetermined transfer agreements are reviewed and discussed both within and between the involved centers. These reviews are processed through a secondary level of review by the trauma PIPS or equivalent committee within the hospital.
- Direct and timely communication between orthopaedic providers at each facility occurs prior to all patient transfers. When it does not occur, the reasons are clearly documented by providers on both ends of the transfer.



- Images and reports are sent to the receiving hospital with the patient. Where possible, images should be made available prior to patient arrival.

\*\*\*Adherence to this indicator should not delay transfer.

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### Open Fractures

- Patients with open fractures receive intravenous antibiotics within 60 minutes of presentation.
  - \*\*\*Optimal antibiotic regimen may vary based on extent of tissue damage and contamination.
- All patients with open fractures are evaluated for the potential need for tetanus vaccination.
- Patients with open fractures are taken to the operating room for surgical irrigation and debridement within 24 hours of presentation.
- Patients with open fractures requiring wound coverage with skin grafting or soft tissue transfers have coverage completed within seven days of injury.

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### Damage Control Orthopaedic Surgery

- All patients with femoral shaft fractures undergo fracture stabilization within the first 24 hours of presentation, including patients with multi-system trauma.
- All patients appropriate for damage control management but who received early definitive management

are identified and reviewed by the trauma PIPS or equivalent committee within the hospital.

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### The Mangled Extremity

- All patients who present to the emergency department with a mangled extremity undergo prompt (as defined by institutional protocol) orthopaedic evaluation.
- All patients with a mangled extremity have timely (as defined by institutional protocol) operative management.
- All patients with a mangled extremity undergo re-debridement and/or definitive soft tissue coverage within seven days of injury.
- All patients with a mangled extremity who do not have timely (as defined by institutional protocol) evaluation or operative management (as defined above) are identified and reviewed by the trauma PIPS or equivalent committee within the hospital.

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### Compartment Syndrome

- All patients with signs or symptoms of compartment syndrome undergo prompt (as defined by institutional protocol) surgical evaluation.
- All patients diagnosed with compartment syndrome undergo emergent fasciotomies of the involved compartments.
- All patients with muscle necrosis that is identified during surgical intervention for compartment syndrome



- are identified and reviewed by the trauma PIPS or equivalent committee within the hospital.
- All patients diagnosed with compartment syndrome who ultimately require an amputation of the involved extremity are identified and reviewed by the trauma PIPS or equivalent committee within the hospital.

### Management of Pelvic Fractures with Associated Hemorrhage

- Patients with hemorrhage from pelvic fractures are evaluated promptly (as defined by institutional protocols) by orthopaedics.
- A team with angiographic capabilities is consulted and promptly (as defined by institutional protocols) evaluates all patients with pelvic fractures, evidence of contrast extravasation on cross-sectional imaging, and either hemorrhage or hemodynamic stability.
- For all hemodynamically unstable patients with pelvic fractures, the time from arrival to initial hemorrhage control via pelvic REBOA, angioembolization, or preperitoneal packing is monitored and reviewed by the trauma PIPS or equivalent committee within the hospital.
- Initiation of pharmacologic deep vein thrombosis (DVT) >48 hours after admission are reviewed by the trauma PIPS or equivalent

committee in the hospital, unless a specific contraindication is documented in the medical record.

### Geriatric Hip Fractures

- All geriatric ( $\geq 65$  years of age) patients with hip fractures and multiple co-morbidities are evaluated by a multidisciplinary team, including, at minimum, personnel with expertise in the care of the geriatric patients.
- All geriatric patients with hip fractures who do not undergo surgical repair within 48 hours are identified and reviewed by the trauma PIPS or equivalent committee within the hospital.
- The rehabilitation process is initiated within 24 hours of admission and is continued through discharge for all geriatric hip fracture patients.

### Management of Pediatric Supracondylar Humerus Fractures

- All patients with radiographic evidence of a supracondylar humerus fracture are promptly (as defined by institutional protocol) evaluated by an orthopaedic surgeon.
- All patients with supracondylar fractures who do not receive timely management (for example, surgical repair within 18 hours for Gartland Type III fractures) are identified and reviewed by the trauma PIPS or equivalent committee within the hospital.





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## APPENDIX B: TRANSFER WORKSHEET

Here is an example of a worksheet that can be used by hospitals to predetermine the specific orthopaedic injuries they are appropriately resourced to optimally manage.

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### Orthopaedic Trauma Worksheet

Indicate which orthopaedic conditions may be managed at your hospital.

#### Chest

- Flail chest
- Multiple rib fractures
- Scapular fracture
- Clavicular fracture
- Sterno-clavicular dislocation

#### Spine

- Cervical spine fracture/dislocation
- T/L spinal fracture/dislocation with neuro impairment
- Vertebral body fracture
- Vertebral burst
- Spinal process fracture
- Compression fracture

#### Pelvis

- Open pelvic fracture
- Stable pelvic ring disruption
- Unstable pelvic ring disruption
- Acetabular fracture
- Pelvic fracture with shock

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#### Extremities

- Open long bone fracture
- Two or more long bone fractures
- Fracture or dislocation with loss of distal pulses
- Extremity ischemia
- Fracture with abnormal neuro exam
- Compartmental syndromes
- Shoulder dislocation
- Acromioclavicular fracture/dislocation
- Proximal humerus fracture
- Distal humerus fracture
- Elbow fracture/dislocation
- Forearm fracture
- Distal radius fracture

- Hand/wrist comminuted fractured with nerve involvement
- Carpal dislocation
- Metacarpal fracture
- Hand amputation
- Finger amputation
- Finger amputation involving phalange
- Phalanx fracture
- Hip fracture
- Femur fracture
- Knee dislocation
- Proximal tibia fracture
- Distal tibia fracture
- Pilon fracture

- Ankle fracture
- Talus fracture
- Calcaneus fracture
- Midfoot dislocation
- Subtalar dislocation
- Metatarsal fracture
- Phalanx fracture
- Our hospital routinely transfers all of these orthopaedic conditions.





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